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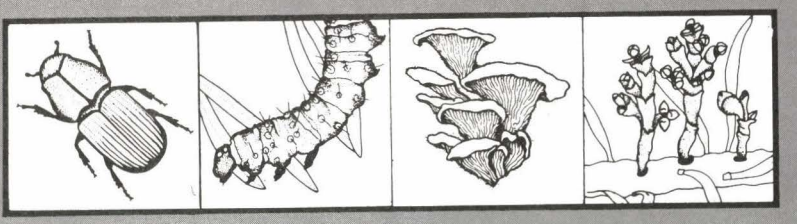

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CONTAINERIZED WESTERN LARCH SEEDLING MORTALITY, USDA FOREST SERVICE NURSERY, COUER D'ALENE, IDAHO

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INTRODUCTION

Western larch (*Larix occidentalis* Nutt.) is one of the most important reforestation species in the Northern Region. In order to meet demands for seedlings, two crops of containerized stock are produced annually at the USDA Forest Service Nursery in Coeur d'Alene, Idaho. The first (spring) crop must be sown as early as February in order to produce two successive crops during the growing season.

During the spring crop of 1987, shortly after seedling emergence, widespread mortality became evident in several seedlots of western larch at the nursery. There was also an unusually high number of empty cells, indicating poor seed germination. Although some damping-off normally occurs in most crops, levels were unusually high for the spring larch crop. Affected seedlings were treated with captan, which is normally used to reduce losses from damping-off. However, treatments were not effective because they were made after most of the mortality became evident. Growers indicated that most mortality occurred over a few days and continued losses after that time were not extensive.

Affected seedlings displayed chlorotic and necrotic foliage; often the bottom tier of needles became necrotic first (fig. 1). Declining seedlings were often concentrated in specific trays or within portions of individual trays (fig. 2). In several cases, most seedlings in individual trays were affected so that the entire tray had to be discarded.

Because of the severity of disease within several seedlots and the potential for greater losses in the future, investigations were conducted to elucidate principal cause(s) of larch seedling mortality at the nursery.

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Due to budget restrictions, only limited photos were available.

Figure 1.--Containerized western larch seedlings with chlorotic and necrotic foliage associated with root infection by *Fusarium* at the USDA Forest Service Nursery, Coeur d'Alene, Idaho.

Figure 2.--Groups of dead and declining western larch seedlings were often concentrated within specific trays or portions of individual trays as shown above. In several cases, entire trays had to be discarded.

MATERIALS AND METHODS

During the periods when most mortality became evident, growers removed individual seedlings that displayed symptoms. In some cases entire trays were removed if most of the seedlings were diseased. Removal of diseased seedlings was initiated to reduce chances of secondary spread to uninfected seedlings.

Five seedlings with decline symptoms were randomly selected from each of five seedlots for laboratory analysis. Roots of the seedlings were thoroughly washed under running tap water to remove adhering soil particles. Lateral root tips were aseptically dissected and placed on a selective medium for *Fusarium* spp. (Komada 1975). Other pieces of the root system were randomly selected so that at least 10 pieces of root were isolated per seedling. In this way, an approximation of the percentage of root system colonized by potentially pathogenic fungi could be ascertained.

For three affected seedlots (see table 1 for descriptions), an entire tray of 200 Leach® pine cells was selected from the trays that had been discarded. Condition of each seedling within the tray was determined: E = empty cell (no seedling emerged); DO = typical post-emergence damping-off symptoms; CNS = seedling with its cotyledons and at least a portion of its stem necrotic; CN = seedling with its cotyledons necrotic but its stem not necrotic; H = seedling with no disease symptoms. For empty cells, ungerminated seed were placed on the selective medium (at least one seed per cell). Roots of seedlings in the DO and CNS categories were washed and placed on the selective medium. Seedlings in the CN and H categories were monitored for several weeks to determine disease symptom progression. After two months, all surviving seedlings were assayed for presence of fungi on their roots using the above-described technique.

Samples of peat-vermiculite soil mixes were screened for presence of *Fusarium* propagules to evaluate the possible role of these mixes as sources of inoculum. Two different lots of soil mix were sampled (each produced during different years with apparently differing peat sources). Standard soil dilution techniques were used for determining *Fusarium* populations (James and Gilligan 1985). Soil mixes were sieved to remove large organic pieces. Dilutions of 1:400 were made in 0.1 percent water agar and I ml dispensed onto plates of selective media for *Fusarium* (Komada 1975). Plates were incubated under cool, fluorescent light for 5 days at about 22 degrees C and examined for presence of Fusarium colonies.

RESULTS

Seedlots most affected are listed in table 1. Also, loss estimates based on the number of entire trays of seedlings that had to be discarded are summarized in the table. Seedlots from at least four National Forests were affected. Growers estimated that losses from this entire crop of western larch amounted to 37,000 seedlings. The resulting losses approximated $5,000 in potential revenue to the nursery.

The major group of fungi associated with diseased seed and seedlings was *Fusarium* spp. These fungi were found on more than 90% of the randomly assayed seedlings with decline symptoms from five seedlots (table 2). Extent of root system colonization varied among the sampled seedlings but ranged from 20 to 62 percent. *Fusarium* spp. were also commonly associated with nongerminated seed (empty cells) and seedling roots of both diseased and asymptomatic seedlings (table 3). Of the three seedlots for which an entire tray was evaluated, lot 4890 had the greatest occurrence of *Fusarium* spp. on seedlings and seed. The other two lots (6064 and 6214) had less *Fusarium*. *Fusarium* spp. were not always isolated from seedlings with disease symptoms. Other isolated fungi included *Trichoderma* spp. and *Cylindrocarpon* spp. The former group are common colonizers of soil mixes (James 1985) which may be antagonistic to or replace pathogens such as *Fusarium* (Papavizas 1985). *Cylindrocarpon* spp. may be pathogenic to conifer seedlings (James 1987a), but they are usually not as aggressive as *Fusarium* spp.

Table 1.—Representative losses of containerized western larch seedlings (spring crop) at the USDA Forest Service Nursery, Coeur d'Alene, Idaho

Greenhouse	Seedlot	Location		Total trays sown	No. trays removed	Percent removed	Est. no. seedlings lost*
		National Forest	District				
25	1928	Lolo	Seeley Lake	47	10	21.3	2,000
25	2792	Kootenai	Libby	171	45	26.3	9,000
25	4044	Lolo	Ninemile	65	2	3.1	400
25	4216	Kootenai	Fisher River	189	28	14.8	5,600
25	4326	Lolo	Superior	35	11	31.4	2,200
25	4890^	Bitterroot	Stevensville	53	5	9.4	1,000
25	6064^	Lolo	Seeley Lake	47	19	40.4	3,800
Subtotal	—	—	—	607	120	19.8	24,000
35	2806	Idaho Panhandle	Wallace	215	6	2.8	1,200
35	6214^	Idaho Panhandle	Fernan	142	3	2.1	600
35	6222	Idaho Panhandle	Sandpoint	142	5	3.5	1,000
Subtotal	—	—	—	499	14	2.8	2,800
Total	—	—	—	1,106	134	12.1	26,800

*Estimated loss based on removal of entire Leach® pine cell tray. This estimate does not include scattered mortality in trays not removed.

^Seedlots from which an entire tray was sampled.

Table 2.--Occurrence of *Fusarium* on randomly selected declining containerized western larch seedlings at the USDA Forest Service nursery, Coeur d'Alene, Idaho.

Seedlot	No. seedlings sampled	No. with roots infected with *Fusarium*	Percent infected	Average infection rate*
2792	5	4	80.0	47.5
4044	5	5	100.0	62.0
4216	5	4	80.0	20.0
4326	5	5	100.0	26.0
6064	5	5	100.0	48.0
Totals	25	23	92.0	41.3

*Based on the proportion of root systems colonized by *Fusarium* spp. (infected seedlings only).

Table 3.--Occurrence of *Fusarium* on western larch seed and seedlings of selected seedlots from the USDA Forest Service Nursery, Coeur d'Alene, Idaho

Seedlot	Seedling condition*	Percent of cells	Percent with *Fusarium***
4890	E	43.0	66.3
	DO	36.0	79.2
	CNS	12.0	83.3
	CN	6.5	84.6
	H	2.5	80.0
Subtotals		100.0	74.5
6064	E	51.5	35.9
	DO	17.5	31.4
	CNS	21.0	26.2
	CN	6.5	46.1
	H	3.5	71.4
Subtotals		100.0	35.0
6214	E	38.5	48.0
	DO	14.0	14.3
	CNS	13.0	15.4
	CN	11.0	95.4
	H	23.5	78.7
Subtotals		100.0	51.5
All lots	E	44.3	49.2
	DO	22.5	53.3
	CNS	15.3	38.0
	CN	8.0	79.2
	H	9.9	78.0
Totals		100.0	53.7

*Condition:

E = Empty cell; no seedling emerged.
DO = Typical post-emergence damping-off.
CNS = Seedlings with necrotic cotyledons and at least a portion of their stem necrotic
CN = Seedlings with necrotic cotyledons
H = Seedlings without disease symptoms.

**Percent of cells with *Fusarium* colonizing either seed or seedling roots.

More than three quarters of the sampled seedlings without disease symptoms were infected with *Fusarium* (table 3). Previous investigations (James et al. 1987) have also indicated that asymptomatic seedling infection is common, especially in container operations. The organisms isolated from diseased seedlings were similar to those isolated from asymptomatic stock, i.e., primarily *F. oxysporum* Schlect. and *F. sambucinum* Fuckel.

It is possible that abiotic factors contributed to the extensive seedling losses experienced at the nursery. Perhaps seedlings were predisposed to disease because of abnormal temperatures or moisture that occurred during the critical period of seed germination and seedling emergence. It has previously been shown that western larch seedlings are especially vulnerable to temperature extremes and pesticide damage during the emergence period (James 1986). Apparently levels of *Fusarium* inoculum available were not limiting; therefore, other factors must have been responsible for the losses experienced. Also, above normal losses occurred on Engelmann spruce seedlings at about the same time (James 1987), most of which were associated with *Fusarium* infections.

Sampled soil mixes failed to yield populations of *Fusarium*. However, the mixes did contain high populations of *Trichoderma* (which were easily assayed on the selective medium used for *Fusarium*). Therefore, it is likely that the major source of *Fusarium* inoculum was from infested seed, although some fusaria have been isolated previously from within greenhouses at the Nursery, primarily on the roots of weeds (James et al. 1987). Samples of ungerminated seed yielded fairly high levels of *Fusarium* (table 3). Therefore, it is recommended that seedlots suspected of harboring high levels of *Fusarium* (such as those with poor germination performance) be screened prior to sowing and perhaps be treated with surface sterilants to reduce amounts of contamination.

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